Noteworthy anatomical and physiological researches.

Nourishment of the embryo and importance of the endosperm in viviparous mangrove plants.

The remarkable phenomena attending the germination of viviparous plants in the Rhizophoreæ and other mangrove plants have been noticed by a number of investigators. In the present paper[1] Haberlandt makes a noteworthy contribution to the knowledge of the subject.

Treub[2] was the first to call attention to the peculiar behavior of the endosperm in the Verbenaceous *Avicennia officinalis* which, with its included embryo, grows out of the micropyle into the cavity of the fruit while the latter is still attached to the tree. Later the placenta pushes out into the fruit in all directions, the endosperm serving as a haustorium to secure the necessary food for the embryo.

Warming[3] observed a similar outgrowth of the endosperm in *Rhizophora Mangle*. He describes it as a large celled clear tissue apparently entirely wanting in food material and extending above the ovule as a micropylar arillus, whose office seemed to be to conduct nourishment from the mother plant to the embryo. However he brought no certain proof to support this view. In this plant, according to Warming, the entire surface of the upper part of the cotyledon is thickly covered with glandular hairs, below which lie scattered secretory or haustorial cells which he calls true sessile glandular hairs.

Goebel[4] described vivipary in certain mangrove plants and also touched upon the haustorial nature of their endosperm. He states that the embryo in the rhizophorous *Bruguiera gymnorhiza* takes part of its nourishment from the cotyledons but that a large portion of the starch of the hypocotyl arises from its own assimilative activity, since a considerable amount of chlorophyll is found in its external tissues. Goebel also

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[1] G. HABERLANDT, Ueber die Ernährung der Keimlinge und die Bedeutung des Endosperms bei viviparen Mangrovepflanzen. Annales d. Jardin botanique d. Buitenzorg. **12:** 91–114. 1894. *pl. 10–12.* Leide: E. J. Brill.

[2] Notes sur l'embryon, le sac embryonnaire et l'ovule. Ann. d. Jardin bot d. Buitenzorg. **3:** 79 ff.

[3] Tropische Fragmente, II. Engler's Jahrb. **4:** 517 ff. 1883.

[4] Pflanzenbiologische Schilderungen, **1:** 113 ff. 1889.

maintains that the endosperm in this plant is consumed by the cotyledons. In the case of *Rhizophora conjugata* the same author considers that the endosperm, by means of the marked lateral growth of its upper portion, possesses the mechanical function of opening widely the micropyle, and thus serves to lead the way for the developing embryo or "cotyledonar bodies" whose upper surface is composed of a richly absorbing plasma tissue.

A. F. W. Schimper[5] has also furnished a valuable contribution to the literature of vivipary in the mangroves, especially in the myrsinaceous *Ægiceras majus* and in *Bruguiera caryophylloides*. In the latter the cells of the testa, rich in plasma, are provided with large nuclei and secrete a ferment. True assimilative activity in this case is greatly hindered by the want of stomata and by the thick cuticle. In *Rhizophora mucronata* the cone-shaped endosperm emerges from the micropyle and is soon perforated by the rapidly growing hypocotyl. The cotyledon is divided into three parts; the upper conical end represents a haustorium and its surface possesses a glandular structure similar to that of the cotyledons of Bruguiera. The central portion is expanded and prevents the heavy embryo from slipping down, while the petiolar basal part, which projects from the pericarp like a collar or crown, serves as a protective sheath for the plumule.

Finally, G. Karsten[6] has made very serviceable studies of the germination of the mangroves.

Haberlandt's observations have been confined principally to three species: *Bruguiera eriopetala*, *Rhizophora mucronata* and *Ægiceras majus*. In the young fruit of the first species can be seen solitary semi-lenticular endosperm cells, rich in plasma, which lie between the cotyledons and seed covering. These are the remains of the primary endosperm. Similar cells are also found in the endospermous slime which fills up the canal resulting from the juxtaposition of the cotyledons. Sometimes a roundish cluster of cells separated by their septa occurs. From the widely open micropyle projects a true endosperm tissue in the form of a collar or arillus, 2–4^{mm} in width. This, however, is not reflexed as is usually the case in this genus and does not surround the embryo, but is intercalated between the calyx and the uppermost part of

[5] Die indomalayische Strandflora, 42 ff. Jena 1891.

[6] Ueber die Mangrove-Vegetation im Malayischen Archipel. Bibliotheca Botanica 22:—1891.

the hypocotyl. To the function of this organ we shall recur soon.

The importance of the above-mentioned semi-lenticular cells has been entirely overlooked by previous writers. According to Haberlandt they serve as starting points for the development of a many layered secondary endosperm which forms the haustoria already mentioned. This secondary endosperm sends between the loose parenchyma cells of the seed coat haustoria-like processes of one to many cells. These haustoria are frequently lobed and possess papillose ends. Their walls are of thick cellulose excepting those of the terminal cells which are thin.

The author sketches the development of this peculiar structure, which finally forms a flattish disk whose cells are easily distinguished from the surrounding parenchymatous tissue by their thickened walls and abundant content of protoplasm. The primary endosperm at this time has become reduced to a few cells. If now the sides of the cotyledons lying next to the testa are examined, their cells will be seen to be arranged radially, with the outer layer colorless and characterized by an abundance of plasma and large nuclei. In this stage of development the cotyledons act only as absorptive organs.

Haberlandt removed the cotyledonary bodies, which at this period are about as large as peas, carefully washed them and gave them a coating of wheat starch. Microscopic examination after twenty-four hours showed that the grains of starch were strongly corroded, thereby confirming the previous supposition of Schimper that the cotyledonary tissue secretes a diastatic ferment. The same corrosion was exhibited by the layer of secondary endosperm. Upon making cross sections through the integument and the endosperm the interesting fact was brought out that in many places solitary endosperm cells send in tube-like processes between the palisade tissue of the cotyledons, often to a depth of two or three layers of cells. These evidently serve to form a point of union between the endosperm and the embryo.

The author next considers the function of the so-called "endosperm collar" which lies between the calyx tube and the upper part of the hypocotyl. At this place the endosperm is thickened and has an uneven outer surface with tooth-like projections. These teeth or lobes extend in length

and send strong haustoria into the calyx tube. The parenchyma cells of the calyx tube lying between these haustoria are marked by their large size and thin walls. Here, to all appearances, the developing embryo secures the greater part of its nourishment. In addition to obtaining food the endosperm collar has a purely mechanical function. The fruit of *Bruguiera eriopetala* falls off when the hypocotyl has reached a length of 8 or 9^{cm}. The young seedling at this stage possesses neither sufficient strength nor firmness, nor does it fall far enough to fix it vertically in the slimy soil. This position is secured by means of the firm, pointed calyx lobes which serve as an anchor. At the same time the strongly turgescent endosperm collar takes up water and increases considerably in thickness, thus acting as a wedge to separate the calyx from the hypocotyl and reminding one of the lodicules in grasses which, according to Hackel,[7] by their rapid swelling push away the glumes and thus effect the opening of the flower.

Haberlandt undertook a quantitative analysis of the chlorophyll in the hypocotyl of *Bruguiera eriopetala*, to ascertain whether there was a sufficient amount present for the necessary assimilative processes. He found the chlorophyll content of the hypocotyl to be rather more than half the amount contained in a single foliage leaf. He also found that in this species there are about five stomata to every square millimeter of hypocotyl surface.

Further investigations are necessary to determine whether other members of the genus Bruguiera possess haustorial cells arising from secondary endosperm, as was found to be the case in *Rhizophora mucronata*, although they do not appear to be of equal importance in the latter plant. In the myrsinaceous species studied, *Ægiceras majus*, the hypocotyl pierces the testa but does not enter the fruit, and the formation of endospermal haustoria takes place only in the region of the placentæ.

The paper here noticed is one of the many important contributions to botanical knowledge which have emanated from the Buitenzorg botanic garden. (Cf. BOTANICAL GAZETTE, **19:** 74. 1894.—G. H. HICKS.

[7] Ueber das Aufblühen der Gräser. Bot. Zeitung **38:** 432. 1880.